LCC - QA71-90

THE VECTOR ROTOR OF SECOND ORDER AS MEANS OF IMPRUVEMENT OF TOOLS FOR AUTOMATION OF IMAGE PREPROCESSING

Alexander Trunov

Petro Mohyla Black Sea National University

Address for Correspondence: Alexander Trunov, First Vice-Principal, as. Professor, Dept. - Automation and CIT., ph. D

Institutional affiliation: Petro Mohyla Black Sea National University, Mykolayiv, Ukraine

E-mail: trunovalexandr@gmail.com

Abstract. The vector rotor of second order, which provide processing of image was introduced and considered. The feature of vector rotor of second order as vector product and step vector were investigated. It was received the algebraical expressions for determination of step vector as under direct action of rotor. The obtained results of modelling and investigation of values coefficients of compression and losses for different type of image, gradations and vector rotor fist and second order. It is shown the examples of applications of vector rotor to preprocessing of images in sensors for hyperspectral analysis.

Keywords: automation; preprocessing; vector rotor second order; controlling rules; operation under rotor vector; expression of step vector; coefficient of compression and losses; hyperspectral sensor.

Introduction. At the present time well known, that coordination is effective technology for control of any complicated manufacture or other socio-economic activity. Theoretical basis of coordination as means for providing of continuity and regularity of control is grounded in [1,2]. The realization of principal coordination as the main central function of process control principal in automated system [2-4] will be reformulated: - just in time; - in accordance with plan; - in compliance with a schedule; - as required and described by specification. The designing special system, which plays a role of a subsystem in the stabilization of process in relation to the predetermined strategy [4]. At present, scientists, based on the study and systematization of technologies [5–10], including bio medical technology [9-10], determined and formed a generalized structure of rehabilitation and photo therapy technological equipment and generalized models of the technological process automation control system. In addition, an analysis of the methods of control over complex automated systems was carried out [9–10]. The main tools for realization of this type technology used hyperspectral analyzer, sources of light, equipment for motion

and orientation in space of sources of light and sensor, microprocessor based on hardware and software and automation system of coordination.

The modern works describing integrated systems of early diagnostic, rehabilitation sensory systems demonstrates, that sensory reflection of parameters of system state was provided for fullness and timeliness of the data about changes of environment [11-23]. That allows to carry out a recognition in real time and immediately reacts in dynamic situation, which predicts of breakdown or faults [24-26]. Situation – dependence qualitative perception and choice of functional behaviour that based on analysis of qualitative simple sensory feed - backs is of its advantages [26]. Particularly it is successive, if simultaneously applied methodology of evaluation by several standards [27] and hyperspectral analysis. The main principal of devices for hyperspectral imaging consists in spatial scanning by projecting a strip of the scene onto a slit and dispersing the slit image with a prism or a grating. These systems have the drawback of having the image processed per lines (with a push broom scanner) and also having some mechanical parts integrated into the optical train. The success of 2-D, 3-D hyperspectral analysis and spectral scanning and distinguishing hyperspectral from multispectral imaging in medical practice at present are discussed and demonstrated in [15-23]. The construction of automation systems, that generates according to doctor prescription or physician diagnosis list of commands and actions for diagnosing system of prevention and rehabilitation based on the analysis of large amounts of video data streams. As was demonstrated in works [28-30] existing methods of compression by extracting frames that do not include changes completely modern requirements to provide compression [31-35]. Currently, a similar problem arises for the early diagnosis, prevention and treatment systems.

One of the promising areas for further improvement of these systems and methods are generally intellectualization microchips - CMOS photodiode arrays by improving the structure converter of each pixel [26] and the integrated use of neural networks [35]. Last built in technology based on testing and analytical studies that are also able to reconfigure. Check out methods of crisp metrology and use the metrology of fuzzy logic variable accuracy of estimates and demand, which lie in the design, assembly in a single housing increases accuracy and speed of colour segmentation [26].

Thus, thanks to coil, the whole device built into existing video and sensor systems, and their signals suitable for application in parallel processing algorithms acceptance of decisions making. Current existing approaches to reduce the volume further calculations using transformed the concept of derivatives, gradients, operators Roberts and Sobolev 31], rotor [33, 34]. However, their application to video processing systems Intelligent information such microarrays require additional studies of their properties and forming machine operations on them and improving methods of decision theory [33, 34].

The main problem, which is not solved is the problem of visual information compression ratios and absence of the methods of algebraic processing and without further losses under playback of visual information. Thus, the problem of finding new opportunities of compression of frame image and study of their properties and formation of mathematical principles using changes in search algorithms and optimization algorithms, recognition and management is important.

The aim of article is to further studying the properties of the rotor as one of the main tools of intellectualization microchip for colour image segmentation, the construction of theoretical principles and search for the missing parts to be used in search algorithms and optimization algorithms.

A. Pointing the problem and properties of second order rotor as key instrument of intellectualization.

Let us consider a image which is formed by rectangular matrix with $Q \times S$ of photo diode. For non-dimensional coordinate: - i vertical; - j horizontal at arbitrary point $p(i, j)$, in Cartesian system of coordinate are given for each pixel the certain value of physical quantity F_{ij} as matrix. The each element of matrix is the vector with three components for *RGB* expansion. The each component of its describes by eight bit number. Let introduce susceptibility threshold F_0 and average weighted value of background F_f. Let introduce the vector of point orientation on point k as vector modular of which equal to length of segment between point $p(i, j)$ and k and orientation of which equal orientation of this segment started at the point $p(i, j)$ and oriented to point k. As proposed in [31, 33, 34] the modular of moment of deviation of physical quantity will be calculated for arbitrary point $p(i, j)$ with coordinates (i, j) for each k-th points from 8 points of surroundings:

$$M^k_{ikjk} = \left(F^k_{i_k j_k} - F_{ij}\right)\sqrt{\left(x^k_{ikjk} - x_{ij}\right)^2 + \left(y^k_{ikjk} - y_{ij}\right)^2} = \\ = \left(F^k_{i_k j_k} - F_{ij}\right) l^k_{ikjk} \quad (1)$$

Here noticed, that k –number of surroundings point for arbitrary point $p(i, j)$ specially calculated from horizontal first right hand side point in anticlockwise direction, $F^k_{i_k j_k}$ – value of function of physical quantity in point k. It necessary to notice, that in vector form vector rotor will be represented as the multiplication of vector point k and vector physical value. For this vector can be taken, for example, one component of color vector which is perpendicular to plane of image. This definition allows to determinate direction of vector

rotor as direction of vector product. It means that vector is oriented as tangent to surface of image at point $p(i, j)$ or contour of plane image at this point. Thus, as results of calculations are determined 8 values of modules of vector of moments at roundabout point $p(i, j)$ and rotor at point $p(i, j)$ can be obtained matrix form:

$$rot^{T}(i,j) = \frac{1}{F_{ij}} \begin{pmatrix} M_{ij}^{1} + M_{ij}^{2} + M_{ij}^{3} + M_{ij}^{4} + \\ + M_{ij}^{5} + M_{ij}^{6} + M_{ij}^{7} + M_{ij}^{8} \end{pmatrix}, \quad (2)$$

where F_{ij} – value of function at point $p(i, j)$ and $M_{ij}^{1} \ldots M_{ij}^{8}$ –noticed correspondingly values of moments for points 1-8 at central point calculated by equation (1). Introduced product ruls:

IF $F_{i+k,j+l} \geq F_{ij}$, and $F_{ij} > F_0$ or $F_{ij} < F_0$, THEN

$$\varphi(k) = sign\left(F_{i_k j_k}^{k} - F_{ij}\right) D_7 \left[\frac{F_{i_k j_k}^{k} - F_{ij}}{F_{ij}}\right] \text{ OTHER } \varphi(k) = 0. \quad (3)$$

In equation (3) are noticed $D_n[\square]$ is n digital operator, which is acts on any quantitative value and each digit of its is transformed by two grade (0;1) comparator. Now is easy to understand, that eight points of surroundings points for arbitrary point $p(i, j)$, make fist full circle. The second full circle start from point nine and finished at point twenty-four. Let introduced vector rotor of second order as:

$$rot^{T}(i,j)_2 = \frac{1}{F_{ij}} \begin{pmatrix} M_{ij}^{1} + M_{ij}^{2} + M_{ij}^{3} + \ldots + \\ + \ldots + M_{ij}^{22} + M_{ij}^{23} + M_{ij}^{24} \end{pmatrix} \quad (4)$$

Thus introduced vector rotor the second order with help of which represented in uniform information about physical value of 24 points at roundabout point $p(i, j)$.

Materials and Methods. Let consider functioning of vector rotor in special case of determination the next point of analysis in search algorithms. We assume that the arbitrary point $p(i, j)$ is the point of contour, then coordinates of next point for analysis determine as operation with new concept of vector rotor of second order:

$$j_{k+1} = j_k + \left(\overline{x}_2^T - \overline{x}_1^T\right) rot_2(j_k, i_k); \quad i_{k+1} = i_k + \left(\overline{y}_2^T - \overline{y}_1^T\right) rot_2(j_k, i_k), \tag{3}$$

where are noticed eight component vectors

$$\overline{x}_1 = \left[I_{1-15,21-24}^{16-20} \right], \quad \overline{x}_2 = \left[I_{1-8,13-23}^{9-12,24} \right], \tag{4}$$

$$\overline{y}_1 = \left[I_{1-11,17-24}^{12-16} \right], \quad \overline{y}_2 = \left[I_{1-19}^{20-24} \right]. \tag{5}$$

In equation (4) – (5) used special notations of auxiliary vector, superscript (upper) index of which shows number of digit with value 1 and in subscript (below) index shows number of digit with values 0 accordingly. The choice of values for vectors $\overline{x}$ and $\overline{y}$ are explained by properties of rotor across the horizontal and vertical line of contour [33]. These segments of straight line in 5 pixels length constrain cell element from below to upper and from left to right. In results of image analysis we formulate axiomatic conclusion: if point of analysis j_k, i_k moved from point of contour to inner point of image, then next value of step equal zero. We can demonstrate, that this result can be received from equation (3) base on properties of rotor and notation (4)-(5) by simple addition and multiplication as algebraic operation made by equations (3):

$$j_{k+1} = j_k - 5 + 5 = j_k; \; i_{k+1} = i_k - 5 + 5 = i_k.$$

This result also demonstrate fact of end of search in contour search algorithm. Thus this coordinate can be inputs to memory and to begin next search of next point of contour. However, in another case of application motion continues in horizontal or vertical direction to inner point of image until first jump of value of rotor. The distance between two points of this class in horizontal or vertical of directions is horizontal or vertical length of image in these directions. The usage values of horizontal or vertical length of image measure from special points allows to re-determinate scaling and angle of turning of image [16].

Results. For modeling and realization new approach to preprocessing of color segmentation reconsider technology described in the articles [26,33,34]. The realization equality of modeling condition for analysis, were generated artificial binary and color images, which after are converted in BMP format.

As result of providing this stage of modeling was simplified technology of experiment and focus was concentrated on analysis cells 3x3 or 4x4 pixels. The investigation of rotor and rotor of second order for different images, figures, segment of line, points allows to conclude, that vector rotor is sensitive for regular changes of on the contour and in specific points as for binary as well as for color images. Latest allows to investigate only individual dynamic changes at specific point in fragment of image, but not full image as it did for examples in delta methods [28, 29, 30]. However, testing and calculating of characteristic for conditions changing of a background leads to possibility and necessity to use different norms. First that calculated under surface of object and second under surface of background of scene as specific characteristic of bio-tissue. Under application different norms increases volume of information, inasmuch as changes of norm change results of logical analysis and diagnosis. For providing of single-valued results of experiment in efficiency of compression algorithms of preprocessing images we take the BMP files. The aim of this comparison is the calculation maximally possible compression coefficients and minimally possible losses coefficients. Information about type of images, number of gradations and values characteristics are shown in tab.1.

Table 1.

Analysis of preprocessing efficiency by vector rotor algorithm

№	Type of image	Number of gradations	Length in horizontal	Length in vertical	Coefficient of compression First order	Coefficient of compression Second order
1	binary	2	1024	768	3,56603	12.5
2	Monochrom	16	1024	768	2,7	5
3	Monochrom	256	1024	768	2,17241	2.7777
4	RGB	16	1024	768	1,89473	3.0487
5	RGB	256	1024	768	1,52307	1.6233

As demonstrated by analysis of data from tab.1 number of gradation significantly affects on the compression coefficients. The coefficient of losses doesn't change and its value is $9{,}76 \times 10^{-4}$ for rotor. It necessary to notice, that value of pixels is determined only with multiple number 3 and 4 simultaneously. It means that number of photodiodes in rows and in colons of matrix are provided by 12. It can be noticed, that efficiency of algorithm preprocessing of images by rotor method based on significant decreasing of file volume. Application rotor of second order is significantly increased of compression coefficient, but increased loses

of information, if not satisfied described upper multiple demand. The necessity and importance of practical application of new methods of preprocessing is demonstrated on fig. 1

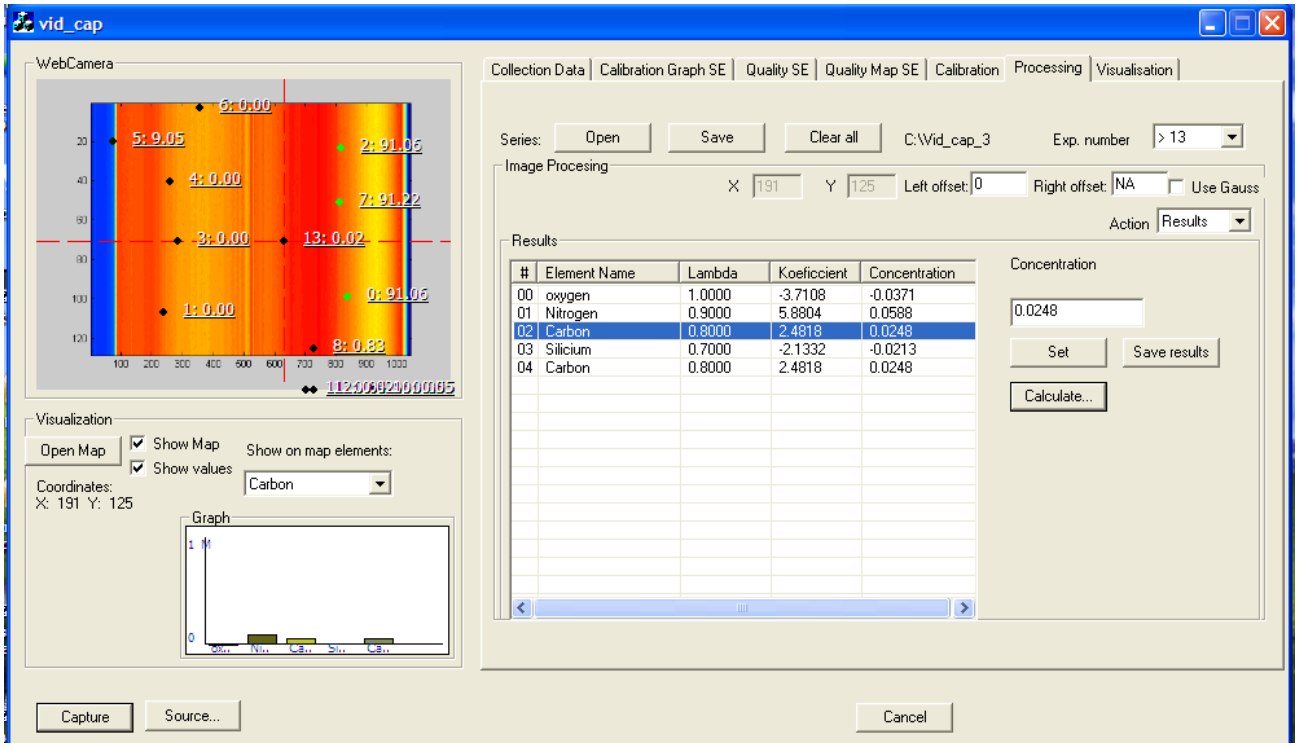

Fig. 1 The image color interference with analyser by rotor vector algorithm and it decoding

On fig. 1 is demonstrated successful attempt to determine direction of analysis by rotor vector (right upper part on fig. 1). So red color line demonstrated, that direction of search and image analysis is perpendicular to fringes. As it shown on fig.1 the new possibility will be decreased value of error and open way for application of hyperspectral analysis.

Discussion:

1. The proposed approach of vector rotor of second order opens new possibility to reconstruct image in 9 or 25 points according to the value of rotor vector first and second order, builds curves of contour, defines the special points.
2. The vector rotor as operator and vector, which is produced in result of its action on array of image is also able for calculation of step vector and coordinate of points from which will be done next step of analysis.

ISSN 2311-1100

Conflict of interest statement: The authors state that there are no conflicts of interest regarding the publication of this article.

Author Contribution: Conceptualization: Alexander Trunov. Data curation: Alexander Trunov. Formal analysis: Alexander Trunov. Writing - original draft: Alexander Trunov. Writing - review & editing: Alexander Trunov.

ORCID

http: //orcid.org/0000-0002-8524-7840

ISSN 2311-1100

REFERENCES:

1. Petrov E. Koordynatsyonnoe upravlenye (menedzhment) protsessamy realyzatsyy reshenyi: Problems of Information Technology, Jornal, Vol. #02(016). 2014: 6-11.
2. Khodakov V, Sokolova N, Kyryichuk D. O razvyty osnov teoryy koordynatsyy slozhnykh system: Problems of Information Technology, Jornal, Vol. #02(016). 2014: 12-22.
3. Fisun M, Horshenova K. Modeliuvannia dynamichnykh protsesiv vitrovoi elektrychnoi stantsii u seredovyshchi gpss: Problems of Information Technology, Jornal, Vol. #01(017). 2015: 145-149.
4. Trunov A. Realization of Paradigm of Prescribed Control of Nonlinaer as the Maximization Adequacy Problem: Eastern-European Journal Enterprise Technologyies, №4(82). 2016: 50-58.
5. Khodakov V, Vezumskiy A. Kharakternye osobennosti odnogo klassa sotsial'no-ekonomicheskikh system: Problems of Information Technology, Jornal, №2(014). 2013: 10-14.
6. Trunov A. Recurrence approximation in problems of modeling and design: Monografy – Mykolayiv: Petro Mohyla BSSU. 2011: 272.
7. Kondratenko YP, Sidenko Ie. Decision-Making Based on Fuzzy Estimation of Quality Level for Cargo Delivery. In book: Recent Developments and New Directions in Soft Computing. Studies in Fuzziness and Soft Computing 317, Zadeh, L.A. et al. (Eds), Springer International Publishing Switzerland. 2014: 331-344, DOI: 10.1007/978-3-319-06323-2_21.
8. Kondratenko Yuriy P, Gerasin Oleksandr S, Topalov Andriy M. Modern Sensing Systems of Intelligent Robots Based on Multi-Component Slip Displacement Sensors, (IDAACS'2015), 24-26 September, Warsaw, Poland, vol. 2. 2015: 902-907.
9. Trunov OM, Belikov OE. Modeling of interaction EMW with biologics objects in during phototherapy: Sience and methodology journal, – T.107. Vol. 94. Ecology. – Mykolayiv: Publisher of MSHU named after. Petro Mohyla. 2009: 23-27.
10. Trunov AN. Peculiarities of the Interaction of Electromagnetic Waves with Bio Tissue and Tool for Early Diagnosis: Prevention and Treatment, in Proceedings are available in IEEE Xplore Digital Library, IEEE 36th International Conference on Electronics and Nanotechnology (ELNANO**) (**April), Kyiv, Ukraine. 2016: 169-174.
11. Beyerer Jürgen, Puente León, Fernando & Frese, Christian. Machine Vision - Automated Visual Inspection: Theory, Practice and Applications. Berlin:Springer. doi:10.1007/978-3-662-47794-6. ISBN 978-3-662-47793-9. Retrieved 10-11; 2016.
12. Graves, Mark & Bruce G. Batchelor Machine Vision for the Inspection of Natural Products. Springer. p. 5. ISBN 978-1-85233-525-0. Retrieved 2010-11-02. Springer Science &

Business Media, 20 nov. 2003.

13. Holton W, Conard. "By Any Other Name".Vision Systems Design. **15** (10). ISSN 1089-3709 Retrieved 2013-03-05:http://www.vision-systems.com/articles/print/volume-15/issue-10/Departments/Inside_Vision/by-any-other-name.html.
14. Owen-Hill Alex. "Robot Vision vs Computer Vision: What's the Difference?": http://www.roboticstomorrow.com/article/2016/07/robot-vision-vs-computer-vision-whats-the-difference/8484/
15. William H Smith. Digital array scanned interferometer US 4976542 A, published 11 December: 1990.
16. Michael W, Kudenov and Eustace L. "Dereniak compact snapshot real-time imaging spectrometer", in Proceedings of SPIE, Vol. 8186 81860W-2, Downloaded from SPIE Digital Library on 06 February to 150.135.50.130. Terms of Use: http://spiedl.org/terms: 2012.
17. Chein-I Chang. Hyperspectral Imaging: Techniques for Spectral Detection and Classification. Springer Science & Business Media. ISBN 978-0-306-47483-5. 31 July; 2003.
18. Hans Grahn, Paul Geladi. Techniques and Applications of Hyperspectral Image Analysis. John Wiley & Sons. ISBN 978-0-470-01087-7.27 September; 2007.
19. Lu G; Fei B. "Medical Hyperspectral Imaging: a review" (Online full text article available). Journal of Biomedical Optics. **19** (1): 10901. Bibcode:2014JBO....19a0901L. doi:10.1117/1.JBO.19.1.010901. PMC 3895860. PMID 24441941, January; 2014
20. "Nikon MicroscopyU. – Confocal Microscopy – Spectral Imaging". http://www.bodkindesign.com/wp-content/uploads/2012/09/Hyperspectral-1011.pdf "OSA – Basic slit spectroscope reveals three-dimensional scenes through diagonal slices of hyperspectral cubes". Schurmer, J.H., Air Force Research Laboratories Technology Horizons, Dec.; 2003.
21. Ellis J. Searching for oil seeps and oil-impacted soil with hyperspectral imagery, Earth Observation Magazine, Jan.; 2001.
22. "SPIE – Journal of Biomedical Optics – Medical hyperspectral imaging: a review",http://biomedicaloptics.spiedigitallibrary.org/article.aspx?articleid=1816617#HardwareandSystems.
23. Dacal-Nieto, Angel; et al. Common scab detection on potatoes using an infrared hyperspectral imaging system. 2011.- pp. 303–312. ISBN 978-3-642-24087-4.
24. Polycarpou M, Trunov A. "Automated Fault Diagnosis in Nonlinear Multivariable Systems Using a Learning Methodology", IEEE Transactions on Neural Networks, vol. 11, no. 1, January. 2000: 91-101.

25. Polycarpou M, Trunov A. “Learning Approach to Nonlinear Fault Diagnosis: Detectability Analysis”, IEEE Transactions on Automatic Control, vol. 45, no. 4, April. 2000: 806-812.
26. Fiesler T, Duong, Trunov A. “Design of neural network-based microchip for color segmentation”, IEEE Transactions on Intelligent Optical Systems. Proceedings of SPIE 4055. 2000: 228-238.
27. Trunov A. Methodology of evaluation alternatives on the basis several etalons. Naukovi pratsi: Naukovo-metodychnyi zhurnal. – Mykolaiv: Vydavnytstvo ChDU im. Petra Mohyly, Vyp. 225. T. 237. Kompiuterni tekhnolohii. 2014: 99-104.
28. Vatolyn D. Metody szhatyya dannykh. M.: «Dyaloh-MYFY». 2003: 338-361.
29. Ryaben'kyy V. Umen'shenye ob’ema potoka vydeodannykh metodom vydelenyya dynamycheskoy sostavlyayushchey Vestnyk Khersonskoho natsyonal'noho tekhnycheskoho unyversyteta. # 2 (38). 2010: 314-318.
30. Ryaben'kyy V. Model' kompleksnoy ob’ektyvnoy otsenky kachestva vydeoyzobrazhenyya v Simulink. Problemy ynformatsyonnykh tekhnolohyy. # 2 (006). 2009: 116-121.
31. Trounov A N. Mathematical aspects of image recognition. Proc. Of International technology 90, Szezecin, Poland. 1990: 479-493.
32. Trunov OM, Volkova SO. Analiz metodiv i zasobiv pidvyshhennya yakosti ta nadijnosti system medychnoyi diahnostyky: Naukovyj zhurnal. – №2. Matematychni mashyny i systemy. – Kyyiv: Instytut problem matematychnyx mashyn i system NAN Ukrayiny. 2008:158-164.
33. Trunov O M. Teoretychni zasady proektuvannya intelektualizovanyx videosensoriv dlya ASUTP : Naukovo-metodychnyj zhurnal. –Mykolayiv: Vyd-vo MDHU im. Petra Mohyly,– Vyp.179. T.191. Komp’yuterni texnolohiyi. 2011: 124-128.
34. Trunov AN. Issledovanie invariantnyh svojstv video ob"ektov v ASUTP [Elektronnij resurs] :Biomedicinskaja inzhenerija i jelektronika. – # 1: 2012.
35. Trunov A. Recurrent approximation as the tool for expansion of functions and modes of operation of neural network, Eastern-European Journal Enterprise Technologyies, 5/4 (83). 2016: 41-48.